

Herrick, Will
Campton, KY
Page 84 of 108

- a. turbine blading replacements with improved shapes (CFD modeling) and materials of construction to increase turbine efficiency and reliability;
- b. implementation of measures to reduce or eliminate droplet formation and the resultant blade erosion preserving turbine reliability and performance; and
- c. turbine/generator inclusion in plant diagnostic and data acquisition system for predictive maintenance (reference area 7c below) to reduce unnecessary maintenance and associated outage time.

Area 3: Plant Auxiliaries

This area focuses on plant auxiliaries including the air heater, feedwater system, cooling water systems, electrical systems, etc. Plant auxiliaries cause approximately 1-2% of lost megawatt-hour (MWh) generation from our coal-fired plants over 20 years old. This can be improved to under 1% with restoration of critical components in this area of the plant. Some examples of recommendations for improved reliability and increased operating efficiencies in these areas are:

- a. air heater or air heater basket replacement with the attendant modern sealing systems;
- b. improved air heater surface design and cleaning system installation to address fouling;
- c. feedwater heater retubing or replacement with upgraded materials to reduce failure rates; and
- d. cooling tower fill improvements.

Area 4: Environmental (Focus on Electrostatic Precipitators)

Precipitator performance has the fourth largest impact on loss of plant availability. This problem almost always manifests itself in the form of load curtailment caused by the potential for opacity excursions. To exacerbate the problem, these curtailments typically occur at very critical capacity supply situations such as periods with high load requirements. Recommendations for mitigation are:

- a. collection plate and electrode upgrades and/or replacement;
- b. collection surface additions (new fields);
- c. various flue gas treatment system installations;
- d. addition of modern control system installations; and
- e. general correction of leakage and corrosion problems.

Area 5: Fuel Flexibility

Many utilities have expanded their coal purchase specifications to leverage the variability in the cost of coal as a means of providing low-cost electricity to their customers. This practice, however, can have an adverse affect on plant reliability due to stress on the plant. It should be noted that although this area is not statistically recognized as a cause of loss of plant availability, fuel related problems are a major part of loss of availability from Area 1 "boiler/steam generator" due to such phenomena as boiler slagging/fouling, limited pulverizer throughput, reduced coal grindability, inadequate primary air systems, etc. Recommendations to reduce or eliminate these limitations are:

- a. coal handling system upgrades to accommodate lower Btu coal;
- b. mill upgrades to accommodate reduced grindability of coal;
- c. ash (bottom and/or fly) system upgrades to accommodate higher ash coal or different ash classes;
- d. additional furnace-cleaning equipment to mitigate different slagging and fouling characteristics of the coals;
- e. draft system upgrades including FD fans, ID fans, combustion air temperature, and related electrical systems to accommodate higher gas volume flow rates; and

Herrick, Will
Campton, KY
Page 85 of 108

- f. precipitator upgrades to accommodate changes in fly ash resistivity and/or quantity.

Area 6: Boiler Water Treatment

This issue goes hand-in-hand with Area 1 described above. Performance of boiler heat transfer surface is highly dependent on the chemistry of the water/stream that keeps the surface cool. Upgrades of the boiler water treatment system should be coordinated with the upgrades described in Area 1. An added benefit of higher water purity standards is faster plant start-ups; and, therefore, a unit can come on-line more quickly and ramp up generation faster resulting in a higher overall generation output. In addition, water purity has a cascading effect increasing the reliability of feedwater heaters and turbine blades and improving condenser performance.

Area 7: Controls and Plant Diagnostic Systems

Modern digital control and diagnostic systems can improve heat rates (generation efficiency), lower emissions, reduce plant startup times, and provide valuable information for outage planning. Recommendations in this regard include:

- a. replacement of outdated analog control with advanced digital control systems;
- b. replacement and/or addition of instrumentation for better control of the unit over a wider range of loads and improved monitoring of critical system components for outage planning;
- c. installation of plant diagnostic and data acquisition systems to perform predictive maintenance reducing unplanned outages and extending on-line time durations between planned outages; and
- d. installation of turbine bypass system hardware and controls to facilitate lower load capabilities, faster unit start-ups and faster ramp rates increasing overall unit productivity.

Area 8: Plant Heat Rejection

For many plants, the highest capacity requirements of the year occur at the same time that they experience severe heat rejection limitations. Summertime cooling lake and river temperatures/water levels can cause load curtailments. Recommendations include:

- a. water intake structure modifications to provide more flexibility during low water levels;
- b. cooling tower additions to provide an alternate heat rejection mechanism; and
- c. cooling lake design modifications (additional surface, redirected flow path, etc.) to increase heat rejection capability.

Summary

Restoration of our 20+-year-old coal-fired plants to a condition similar to those that are under 20 years through the recommendations described in these eight areas can create approximately 10,000 MWs of additional availability from existing assets. We would expect this number to grow significantly as we increase utilization of our older plants to meet growing demand. Without implementing these recommendations, the forecasted increases in utilization will accelerate failures in these older facilities increasing the need for the recommendations we have identified here.

Herrick, Will
Campton, KY
Page 86 of 108

Of particular interest is that 90% of the increased availability identified will come from component replacement and other projects involving the boiler/steam generator. The boiler/steam generator has been the focus of the EPA's allegations in its recent reinterpretation of the New Source Review program as part of its power plant enforcement initiative.

Increasing Generation Output of Existing Units

The maximum demonstrated generating capacity (MDGC) of coal units older than 20 years, as identified above, is conservatively estimated to total approximately 220,000 MWs. The existing operating capacity is estimated to be 200,000 MWs (due to deratings). This group of plants has the potential for both capacity restoration (20,000 MWs) and/or capacity maximization (20,000 MWs). Thus, the total amount of potential increased MW output of this existing group of units is approximately 40,000 MWs. This increased capacity could be achieved within 36 months.

If all existing conditions resulting in a derating could be addressed, approximately 20,000 MWs of increased capacity could be obtained from regaining lost capacity due to unit deratings. This increase would be achieved using the approaches and techniques in Table 1 below.

Approximately an additional 20,000 MWs of capacity could be gained if it were possible to increase heat input and/or electrical output from generating equipment while still maintaining the acceptable design margins and allowable code ratings of the equipment. The approaches and techniques would be similar to those for regaining capacity, as indicated in Table 1.

These approaches and techniques could only be logically pursued by the facility owners if it was clearly understood that the increased availability and/or electrical output would not trigger New Source Review (NSR) and if repowering or construction of new clean coal technologies would be subject to the streamlined permitting authorized by the 1990 CAA Amendments.

The techniques to recover lost capacity and to increase capacity above MDGC have been collected from a combination of research studies by utility industry organizations (such as EPRI) and actual case studies (such as those outlined below) which had benefits for plant owners. They are summarized in Table 1 below.

Herrick, Will
Campton, KY
Page 87 of 108

TABLE 1
Techniques and Approaches for Coal-Fired
Power Plants Capacity Restoration and Increase

Capacity Increase Method	Capacity Restoration	Efficiency/Capacity Increase	Fuel Conversion/Repowering
Installation of improved air pollution control equipment	X	X	X
Steam turbine modernization improvements and upgrades	X	X	
Coal washing	X	X	
Coal switching	X	X	
Repowering with CFB technology			X
Consolidation of multiple, smaller inefficient units to larger, more efficient units		X	X
Operating above the nameplate but within the plant design	X	X	
Control system improvements	X	X	
Plant efficiency improvements	X	X	

The techniques and approaches listed in Table 1 have been implemented with proven results. The following highlights are from case studies.

- SCR and FGD emissions control equipment was installed on a coal-fired generating station to reduce emissions of SO_x and NO_x. In order to offset the increased auxiliary load (16 MWs) of these new systems, an upgrade of the original 500-MW (nominal rating) steam turbine was performed. The upgrade consisted primarily of a new high-efficiency, high-pressure rotor with increased number of stages and an optimized steam path. The upgrade resulted in an output increase of approximately 15 MWs, almost offsetting the auxiliary load increase from the new emission controls.
- Turbine upgrades were completed on two 400-MW rated units to obtain an additional 25 MWs per unit. No additional steam was required from the boiler. No changes were made to the boiler. A more aerodynamic steam path through the turbine was designed and installed.
- Turbine upgrades were incorporated into another unit, nominally rated at 500 MWs achieving an additional 25 MWs. In this case, more steam had to be generated in the boiler and the steam turbine was upgraded.
- Coal cleaning is a process whereby a coal that is high in ash and sulfur is "washed." As a result, the coal is lower in both ash and sulfur content and higher in thermal value. The method consists of a multi-circuit wet process where water is used for screening and separation. Coal cleaning is a cost-effective means of separating ash and sulfur from coal, which in turn reduces opacity and SO₂ emissions. This enables one facility to continue to use local, lower cost, higher ash and sulfur coal and meet environmental limits. Without this coal cleaning process, the facility's load would be limited by approximately 10% due to opacity restrictions.
- Coal switching is an alternative to coal cleaning. In some cases where coal has been switched to reduce SO_x emissions, the capacity may be impaired unless fuel handling systems are upgraded to allow efficient use of lower sulfur fuels.
- Repowering with CFB technology is an alternative to installing NO_x and SO_x emissions equipment. The use of this technique is highly site and fuel specific.
- Capacity increases can be accomplished by taking a brownfield site with several smaller old units, and repowering the site with a single large unit. This will require the full environmental permitting

Herrick, Will
Campton, KY
Page 88 of 108

process. It is a technique that is highly site specific and economically driven. To make the economics attractive, it is important that the units are running at low dispatch levels, so income losses are minimized, and the site can be readily cleared for construction of the larger unit.

- *Control system improvements can increase capacity in older plants. Modern control systems can improve efficiency and reduce emissions by optimizing the combustion process. General improvements to plant efficiency can be obtained by improved operating and maintenance practices along with targeted equipment improvements.*

Note: The additional 20,000 MW that can be achieved by capacity restoration described in this section includes the 10,000 MW of capacity that can be recovered due to deteriorated availability described earlier in the report.

Opportunities for Greenfield Sites and Repowering Existing Facilities with Pulverized Coal Power Generation

As a result of ongoing technology development, new and retrofitted pulverized coal power plants have achieved outstanding emissions performance for NO_x, SO_x, and particulates. Similarly, continued advances in the steam cycle continue to provide higher net plant efficiencies. As a result, new pulverized coal-fired power plants are now commercially available with minimal emissions and with very favorable total production cost. Repowering of an old existing coal-fired power plant with a single modern generating unit equipped with commercially proven emissions controls results in significant reductions in total tons of emissions, even while substantially increasing the total megawatt-hour output of the facility. A case study of repowering an actual old coal-fired plant with a unit utilizing current technology showed a 32% higher design capacity, achieving triple the total electrical output, an 87% reduction in tons of NO_x and SO_x up the stack, and a 42% reduction in total electricity production costs.

Pulverized Coal Technology Options

The configuration of today's state-of-the-art pulverized coal power plant is primarily dependent on the sulfur quantity of the coal to be utilized.

Low sulfur coals will most economically utilize a dry scrubber and baghouse for SO₂ and particulate control. Wet scrubbers can also be utilized with the benefit of producing a useful byproduct (gypsum).

Higher sulfur coals will utilize a wet scrubber and precipitator or baghouse for SO₂ and particulate control.

NO_x emissions will be controlled by both Low NO_x Burners (LNB) and Selective Catalytic Reduction (SCR).

The boiler/turbine steam cycle will vary from a standard subcritical cycle to an advanced supercritical cycle depending on project requirements and fuel costs.